

Claims

1. A method of analysis of an object, the method including the steps of:
generating non-planar penetrating radiation;
5 diffracting the radiation from a monochromator to provide a beam of
monochromatic penetrating radiation;
irradiating a portion of the object with the beam;
diffracting radiation that passes through the object onto a detector from
an analyser;
10 rotating the analyser through a plurality of angular positions; and
measuring the intensity of the radiation incident on the detector as a
function of analyser position.

2. The method of claim 1, including the step of determining a complex
15 scattering function of the portion of the object under analysis from the intensity
measurements.

3. The method of claim 1 or 2, including the step of passing the beam of
radiation through a slit prior to the beam's incidence on the object, the slit size A
20 in a direction transverse to the direction of propagation of the beam being
calculated such that:

$$A \leq \lambda / \delta\theta$$

where λ is the wavelength of the incident radiation, and
 $\delta\theta$ is the optical resolution of the apparatus used in implementing
25 the method.

4. The method of any preceding claim, wherein the analyser is rotated in
incremental steps α :

$$\alpha \leq \delta\theta/2$$

30 where $\delta\theta$ is the optical resolution of the apparatus used in implementing
the method.

5. The method of any preceding claim, including the use of a PIN diode
detector to detect the radiation reflected from the analyser.

6. The method of any preceding claim, wherein the radiation is produced using a characteristic line source.

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7. The method of claim 6, wherein the characteristic line source is a rotating anode source.

10 8. The method of any preceding claim, including the step of calculating a complex scattering amplitude of the irradiated portion of the object from the detected intensities, and including the step of determining a complex scattering function of the irradiated portion by taking an inverse Fourier Transform of the complex scattering amplitude.

15 9. The method of claim 8, including the steps of:
normalising the detected intensities;
calculating the modulus of the complex scattering amplitude from the normalised intensity;
calculating phase information for the complex scattering amplitude
20 from the modulus of the complex scattering amplitude; and
determining the complex scattering amplitude from the modulus and phase information.

25 10. The method of claim 2, 8 or 9, including the step of determining a complex refractive index profile of the irradiated portion of the object from the complex scattering function.

30 11. Apparatus for the analysis of an object, the apparatus including:
a source of non-planar penetrating radiation;
a monochromator for diffracting the non-planar penetrating radiation to provide a beam of monochromatic penetrating radiation;
a detector for detecting radiation that passes through the object;
an analyser for diffracting radiation that passes through the object onto the detector;

means for rotating the analyser between a plurality of angular positions;
and
means for recording the intensity of the radiation incident on the detector
as a function of analyser position.

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12. The apparatus of claim 11, including means for determining a complex scattering function of the portion of the object under analysis from the intensity measurements.

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13. The apparatus of claim 11 or 12, including a slit member defining a slit through which the radiation beam passes prior to the beam's incidence on the object, the slit size A in a direction transverse to the direction of propagation of the beam being such that:

$$A \leq \lambda/\delta\theta$$

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where λ is the wavelength of the incident radiation, and
 $\delta\theta$ is the optical resolution of the apparatus.

14. The apparatus of claim 11, 12 or 13, wherein the analyser is rotated in incremental steps α :

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$$\alpha \leq \delta\theta/2$$

where $\delta\theta$ is the optical resolution of the apparatus.

15. The apparatus of any of claims 11 to 14, wherein the detector comprises a PIN diode detector.

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16. The apparatus of any of claims 11 to 15, wherein the radiation source is a characteristic line source.

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17. The apparatus of claim 16, wherein the radiation source is a rotating anode source.

18. The apparatus of claim 12, wherein the means for determining the complex scattering function includes means for calculating a complex scattering amplitude of the irradiated portion of the object from the detected intensities,

and means for determining a complex scattering function of the irradiated portion by taking an inverse Fourier Transform of the complex scattering amplitude.

- 5 19. The apparatus of claim 18, including:
means for normalising the detected intensities;
means for calculating the modulus of the complex scattering
amplitude from the normalised intensity;
means for calculating phase information for the complex scattering
10 amplitude from the modulus of the complex scattering amplitude; and
means for determining the complex scattering amplitude from the
modulus and phase information.

20. A method of analysis of an object, the method including the steps of:
15 generating penetrating radiation;
diffracting the radiation from a monochromator to provide a beam of
monochromatic penetrating radiation;
passing the beam of radiation through a slit, the slit size A (in a direction
transverse to the direction of propagation of the beam) being calculated such
20 that:

$$A \leq \lambda/\delta\theta$$

- where λ is the wavelength of the incident radiation, and
 $\delta\theta$ is the optical resolution of the apparatus used in implementing
the method;
25 irradiating a portion of the object with the beam;
diffracting radiation that passes through the object onto a detector from
an analyser;
rotating the analyser through a plurality of angular positions; and
measuring the intensity of the radiation incident on the detector as a
30 function of analyser position.

21. The method of claim 20, including the step of determining a complex scattering function of the portion of the object under analysis from the intensity measurements.

22. The method of claim 20 or 21, wherein the penetrating radiation is non-planar penetrating radiation.

- 5 23. The method of any of claims 20 to 22, wherein the analyser is rotated in incremental steps α :

$$\alpha \leq \delta\theta/2$$

where $\delta\theta$ is the optical resolution of the apparatus used in implementing the method.

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24. The method of any of claims 20 to 23, including the use of a PIN diode detector to detect the radiation reflected from the analyser.

- 15 25. The method of any of claims 20 to 24, wherein the radiation is produced using a characteristic line source.

26. The method of claim 25, wherein the characteristic line source is a rotating anode source.

- 20 27. The method of any one of claims 20 to 26, including the step of calculating a complex scattering amplitude of the irradiated portion of the object from the detected intensities, and including the step of determining a complex scattering function of the irradiated portion by taking an inverse Fourier Transform of the complex scattering amplitude.

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28. The method of claim 27, including the steps of:

normalising the detected intensities;

calculating the modulus of the complex scattering amplitude from the normalised intensity;

- 30 calculating phase information of the complex scattering amplitude from the modulus of the complex scattering amplitude; and

determining the complex scattering amplitude from the modulus and phase information.

29. The method of claim 21, 27 or 28, including the step of determining a complex refractive index profile of the irradiated portion of the object from the complex scattering function.

- 5 30. Apparatus for the analysis of an object, the apparatus including:
a source of penetrating radiation;
a monochromator for diffracting the penetrating radiation to provide a
beam of monochromatic penetrating radiation;
a slit member defining a slit through which the beam passes prior to the
10 beam's incidence on the object, the slit size A in a direction transverse to the
direction of propagation of the beam being such that:
$$A \leq \lambda/\delta\theta$$

where λ is the wavelength of the incident radiation, and
 $\delta\theta$ is the optical resolution of the apparatus;
15 a detector for detecting radiation that passes through the object;
an analyser for diffracting radiation that passes through the object onto
the detector;
means for rotating the analyser between a plurality of angular positions;
and
20 means for recording the intensity of the radiation incident on the detector
as a function of analyser position.

31. The apparatus of claim 30, including means for determining a complex
scattering function of the portion of the object under analysis from the intensity
25 measurements.

32. The apparatus of claim 30 or 31, including a slit member defining a slit
through which the radiation beam passes prior to the beam's incidence on the
object, the slit size A in a direction transverse to the direction of propagation of
30 the beam being such that:

$$A \leq \lambda/\delta\theta$$

where λ is the wavelength of the incident radiation, and
 $\delta\theta$ is the optical resolution of the apparatus.

33. The apparatus of claim 30, 31 or 32, wherein the analyser is rotated in incremental steps α :

$$\alpha \leq \delta\theta/2$$

where $\delta\theta$ is the optical resolution of the apparatus.

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34. The apparatus of any of claims 30 to 33, wherein the detector comprises a PIN diode detector.

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35. The apparatus of any of claims 30 to 34, wherein the radiation source is a characteristic line source.

36. The apparatus of claim 35, wherein the radiation source is a rotating anode source.

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37. The apparatus of claim 31, wherein the means for determining the complex scattering function includes means for calculating a complex scattering amplitude of the irradiated portion of the object from the detected intensities, and means for determining a complex scattering function of the irradiated portion by taking an inverse Fourier Transform of the complex scattering amplitude.

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38. The apparatus of claim 37, including:

means for normalising the detected intensities;

means for calculating the modulus of the complex scattering

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amplitude from the normalised intensity;

means for calculating phase information for the complex scattering amplitude from the modulus of the complex scattering amplitude; and

means for determining the complex scattering amplitude from the modulus and phase information.

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39. A method of analysis of an object, the method including the steps of:

irradiating a portion of the object with a beam of monochromatic x-rays;

detecting the intensity profile of an angular spectrum of the x-rays

emerging from the irradiated portion; and

determining a complex scattering function for the irradiated portion of the object under analysis.

40. A method of analysis of an object, the method including the steps of:

5 irradiating a portion of the object with a beam of monochromatic x-ray radiation;

diffracting x-rays emerging from the sample into an x-ray detector using an analyser means; and

10 obtaining an angular spectrum of non-Bragg diffracted x-ray intensities as a function of angular position of the analyser means.

41. A method of analysis of an object, the method including the step of collecting generic x-ray diffraction data from a portion of the object and

15 analysing the data to obtain a complex refractive index of the sampled portion in a direction transverse to the beam propagation.